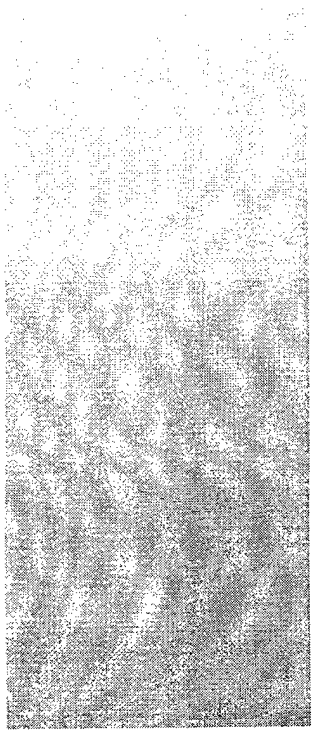
Rockwell GPS

GPS for Munitions

Bryan Wesner

June 1998



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GPS for Munitions

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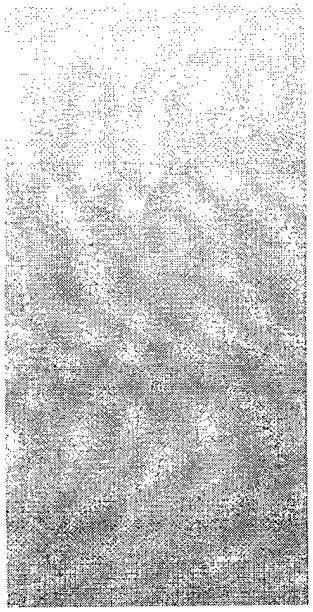
Agenda

- **Introduction**
- **Missile & Munition Overview**
- **PGM-GRAM Roadmap**
- **Artillery Applications/Programs/Status**
  - Low Cost Competent Munition
  - Competent Munition Technology Demonstration
  - ERGM Demonstration
  - Competent Munition ATD
- **Technology Focus**
- **Summary**



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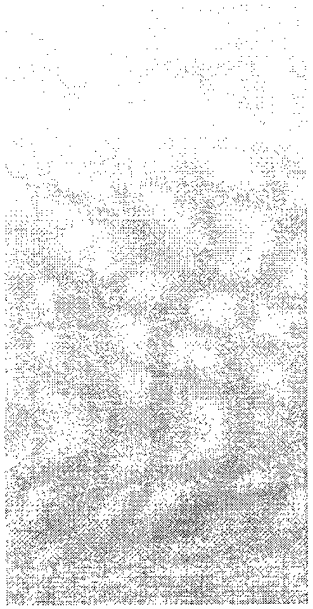
Introduction

Historically GPS has provided guidance for High Value Missile platforms

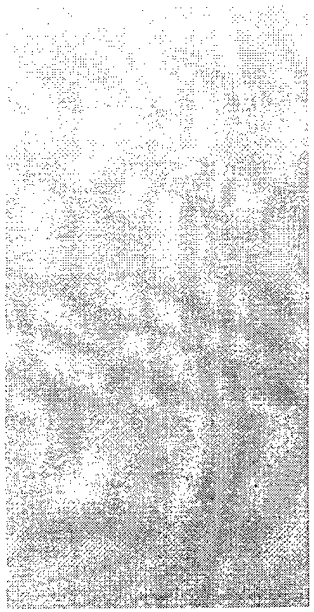
Technology advances have made GPS a viable means of providing accuracy enhancement for all classes of Missiles and Munitions



Missile & Munition Overview

■ Rockwell Collins is the leading producer of GPS receivers for Munitions

LCCM	CMATD (5" Artillery)
LRAS3 (Attitude system)	ATACMS (Missile/Launcher)
CMTD (155mm Artillery)	JDAM (2000 lb. bomb)
ERGM Demo	SLAM-ER
JASSM	AGM-130
SLAM	TLAM Block III



■ GPS to meet wide range of armament needs

- All classes of competent munitions needs met by GPS ie... Missiles, Bombs, Rockets, Artillery and Mortars

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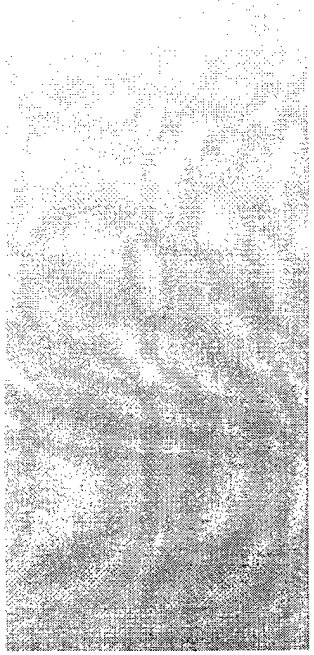
Missile & Munition Overview

- **Precision Guided Munitions (PGM) products have unique requirements**
  - Extreme environments, restricted size, jamming, acquisition and navigation performance
- **Products for Munitions programs utilize common Collins GPS technology components**
  - Custom GPS signal processing ASICs
  - Advanced P/Y GPS Software functionality
- **Historically PGM applications required custom products**



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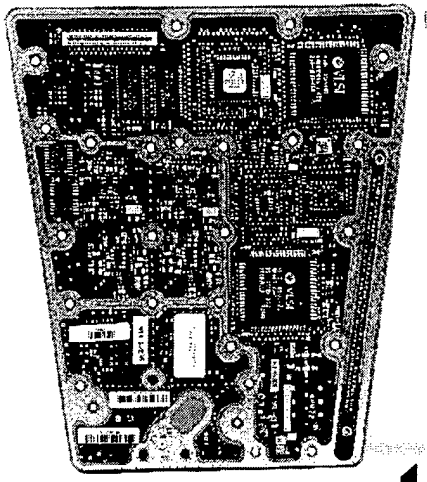
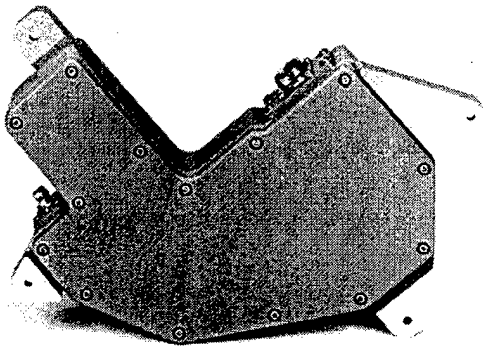
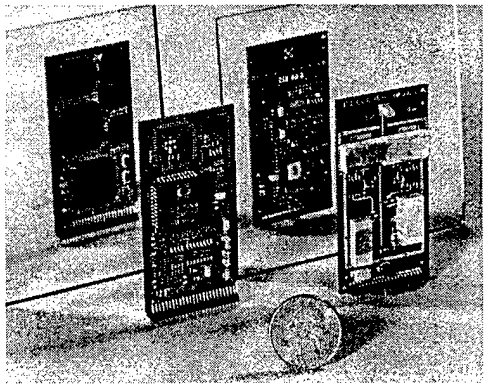
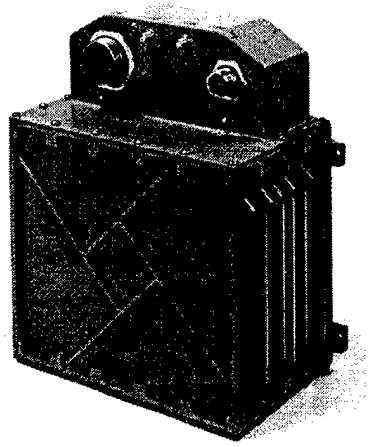
Missile & Munition Overview

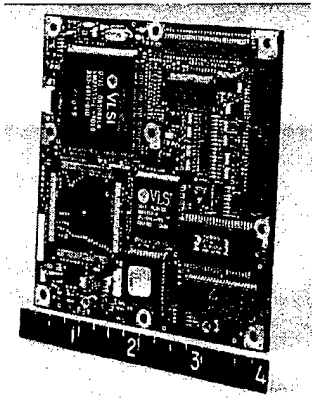




Products customized by each application







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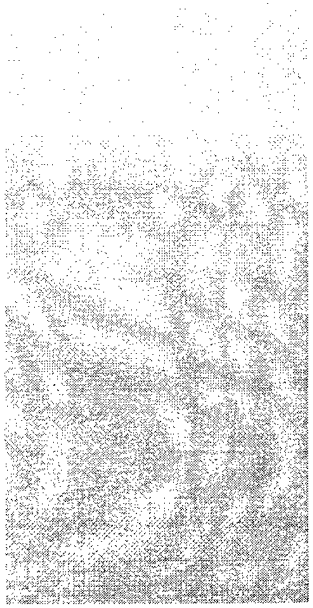
Missile & Munition Overview

- **Reducing size and increasing capability & performance of P/Y GPS is expanding application to all classes of competent munitions**
- **Two major application types identified:**
  - Precision Guided Munition
    - ➢ *Missiles, Rockets, and Bombs*
  - Competent Artillery and Mortars
    - ➢ *Army 155mm and Navy 5”*
    - ➢ *Mortars*



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Missile & Munition Overview

- **GPS based solutions for high-g, gun launched competent munitions are maturing key technologies**
  - GPS ASIC integration & High density interconnect
  - Robust oscillator solutions
- **PGM-GRAM provides means of reducing development and integration costs**

  (Precision Guided Munition - GPS Receiver Application Module)
  - *Open architecture interface standard*
    - Electrical & Interface Messages
  - **Common interfaces allow insertion of technology updates without platform re- integration**

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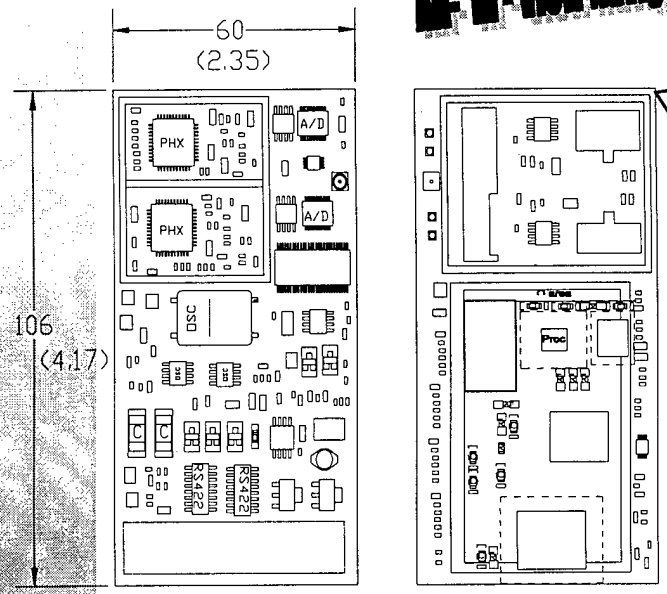
PGM-GRAM Roadmap

Technology insertions easily achieved !

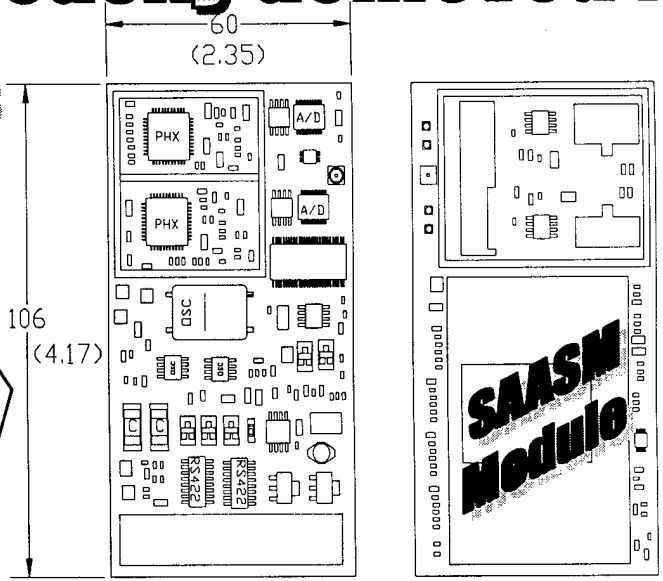
3 Volt Operation

Higher A/J Solutions

All - In - View Navigation



SAASM



Direct - Y code

Lm Code

Improved Oscillator Implementations

Technology Insertion with a common physical and Integration Interface

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PGM-GRAM Roadmap

■ Status

- Development of miniaturized PGM-GRAM underway
  - ➢ *GRAM interface and form factor*
  - ➢ *PPS-SM product supports customer integration*
    - ■ Units available 1Q CY '99
- SAASM insertion planned as follow-on technology insertion
  - ➢ *Maintains GRAM backward compatibility*
  - ➢ *Provides reduced logistics burden with Black Key capability*
  - ➢ *Integration units available 4Q CY '99*

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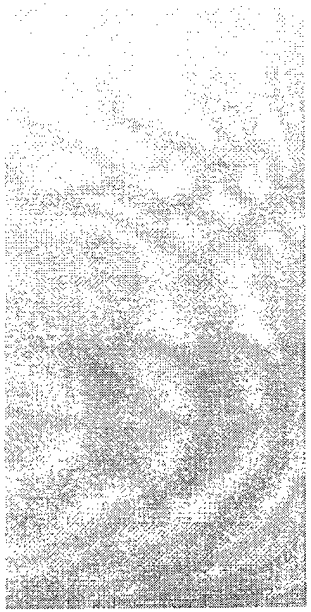
Why Use GPS in an Artillery Shell ?

- **Fielded rounds are unguided**
  - Smart fuzing utilized for increased effectiveness
- **Weapon Range Is Increasing**
- **Improved Accuracy a Necessity for Long Range**
  - Less Munitions required per Engagement
  - Reduces Mission Time
  - Allows for More Missions per Battlefield Day
  - Lower Demand and Cost on Logistic Chain
  - Increases Survivability: "Shoot and Scoot"
  - Reduces Collateral Damage



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Competent Artillery Approaches

■ Collins is supporting three different approaches to Competent Munitions

- Auto-registration
  - ➢ *2 - 3X accuracy improvement over 20 to 50 km*
    - Low Cost Competent Munition (LCCM)
- Range only 1-D Correction
  - ➢ *2.5 - 6X accuracy improvement for 20 to 50+ km*
    - Competent Munition Technology Demonstration (CMTD)
- Fully guided 2-D Correction
  - ➢ *4 - 15+X accuracy improvement for 30 to 100 km*
    - Extended Range Guided Muniton (ERGM) Demo
    - Competent Munition ATD (CMATD)

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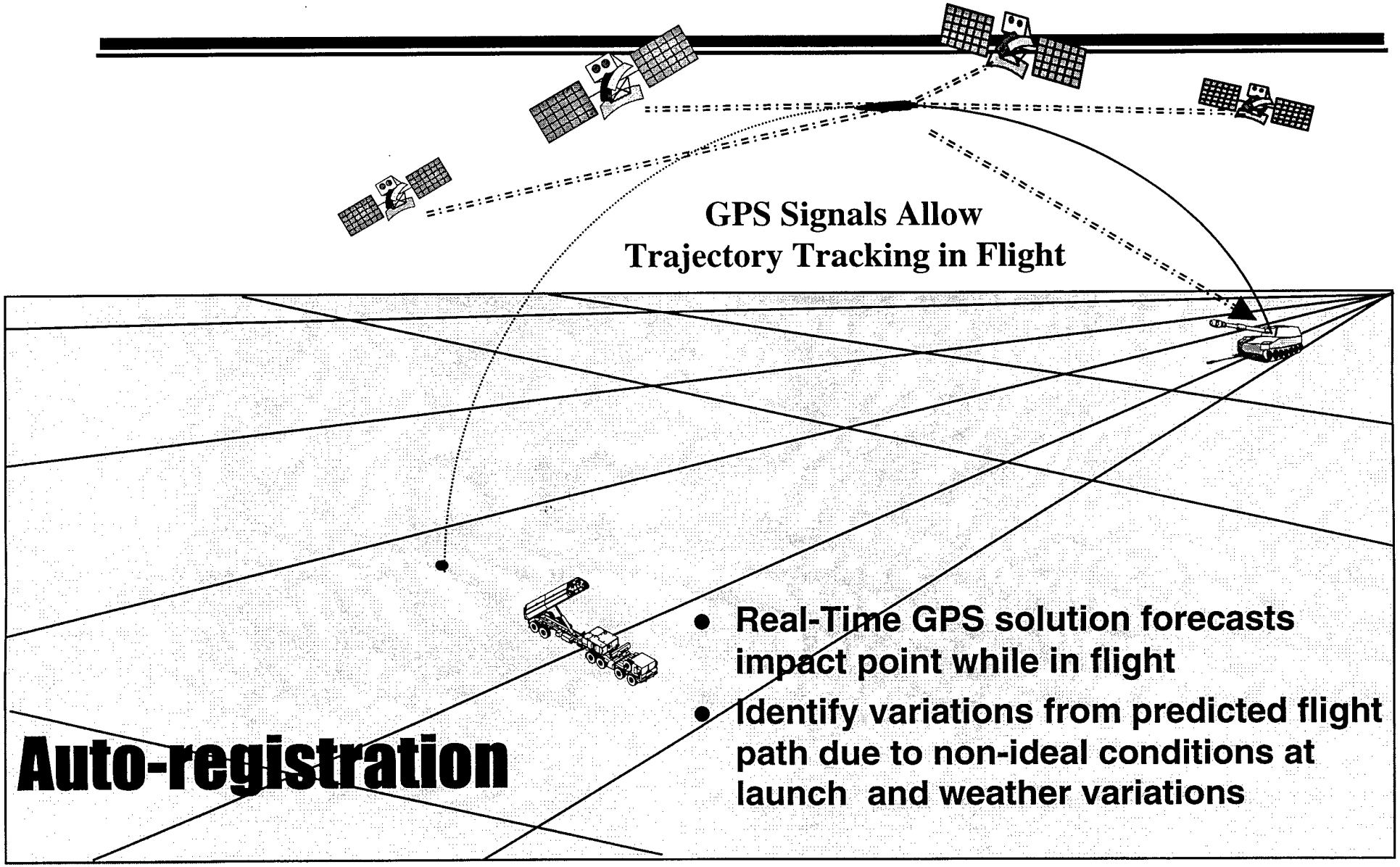

Auto-registration

- Real-Time GPS solution forecasts impact point while in flight
- Identify variations from predicted flight path due to non-ideal conditions at launch and weather variations

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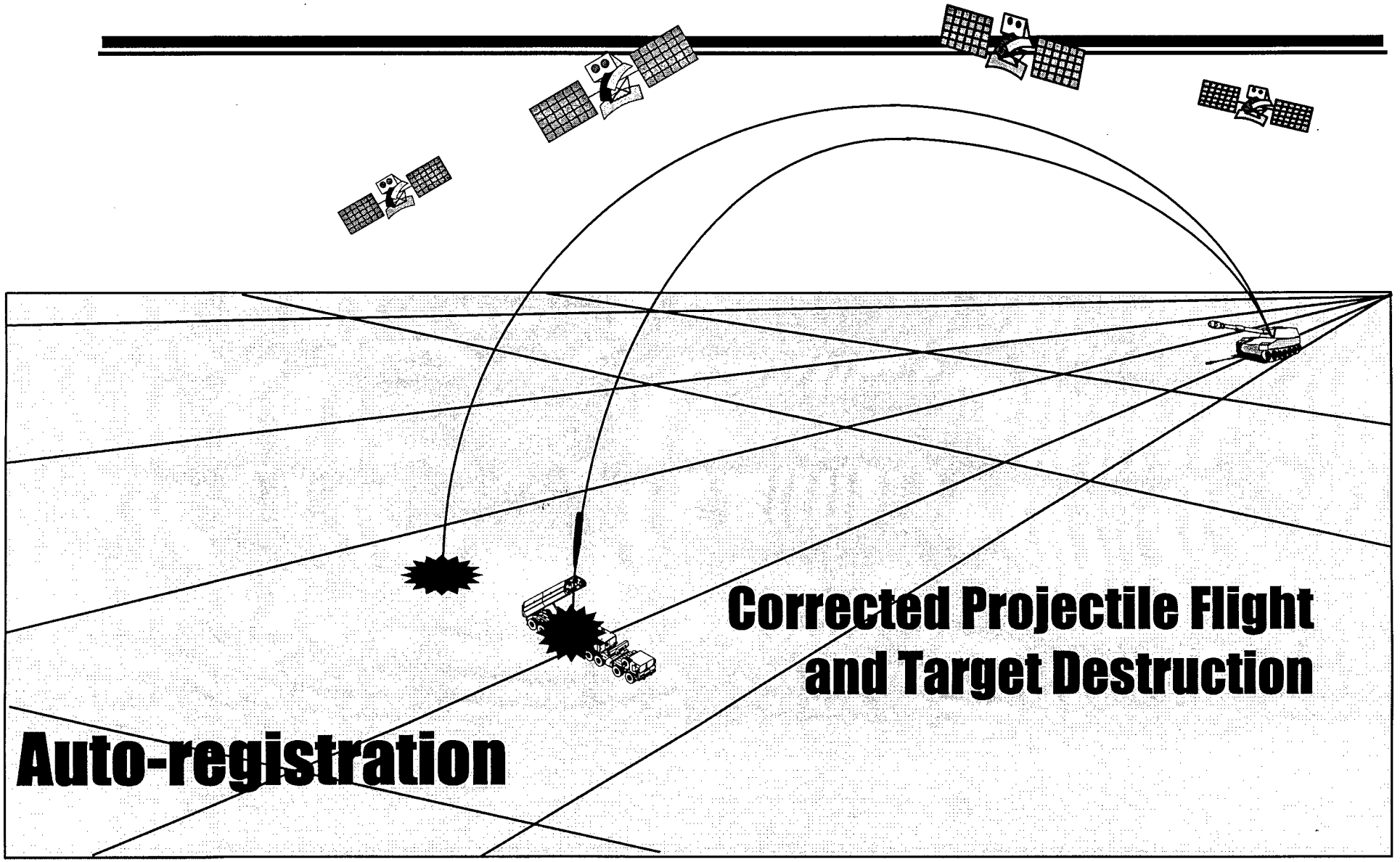

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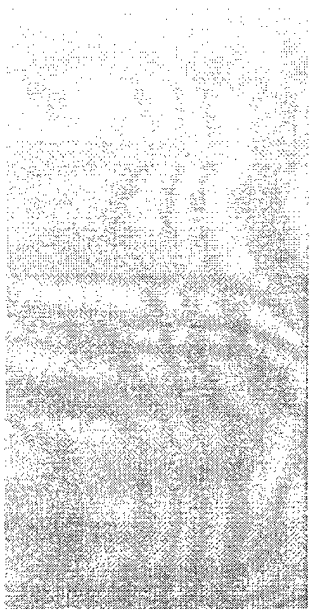
Low Cost Competent Munition Program

■ PURPOSE

- Compute trajectory of first round fired
  - ➢ *GPS Autoregistration Fuze (GARF)*
    - ■ RF repeater on shell rebroadcasts GPS signals
  - ➢ *Ground Based Receiver (GBR) completes GPS processing*
- Calculate correction and fire for effect

■ Status

- Development of the GPS system is complete
  - ➢ *All Fuze and Ground receiver components delivered*
- Test firings completed - May 98 @ Yuma
  - ➢ *Real-Time GPS processing unsuccessful*
  - ➢ *Post flight data analysis ongoing*



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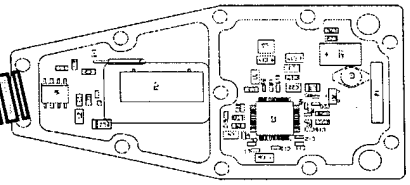
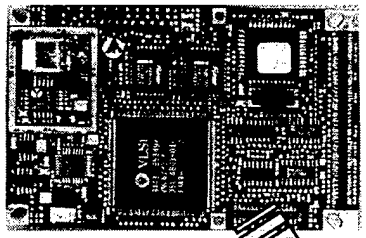
Low Cost Competent Munition Program

GPS AutoRegistration Fuze



S - Band Link



MPE 1.12

S to L band Translators	GPS All-in-View Receivers
Ground Based Receiver	
P(Y) Differential Base Station	Application Computer

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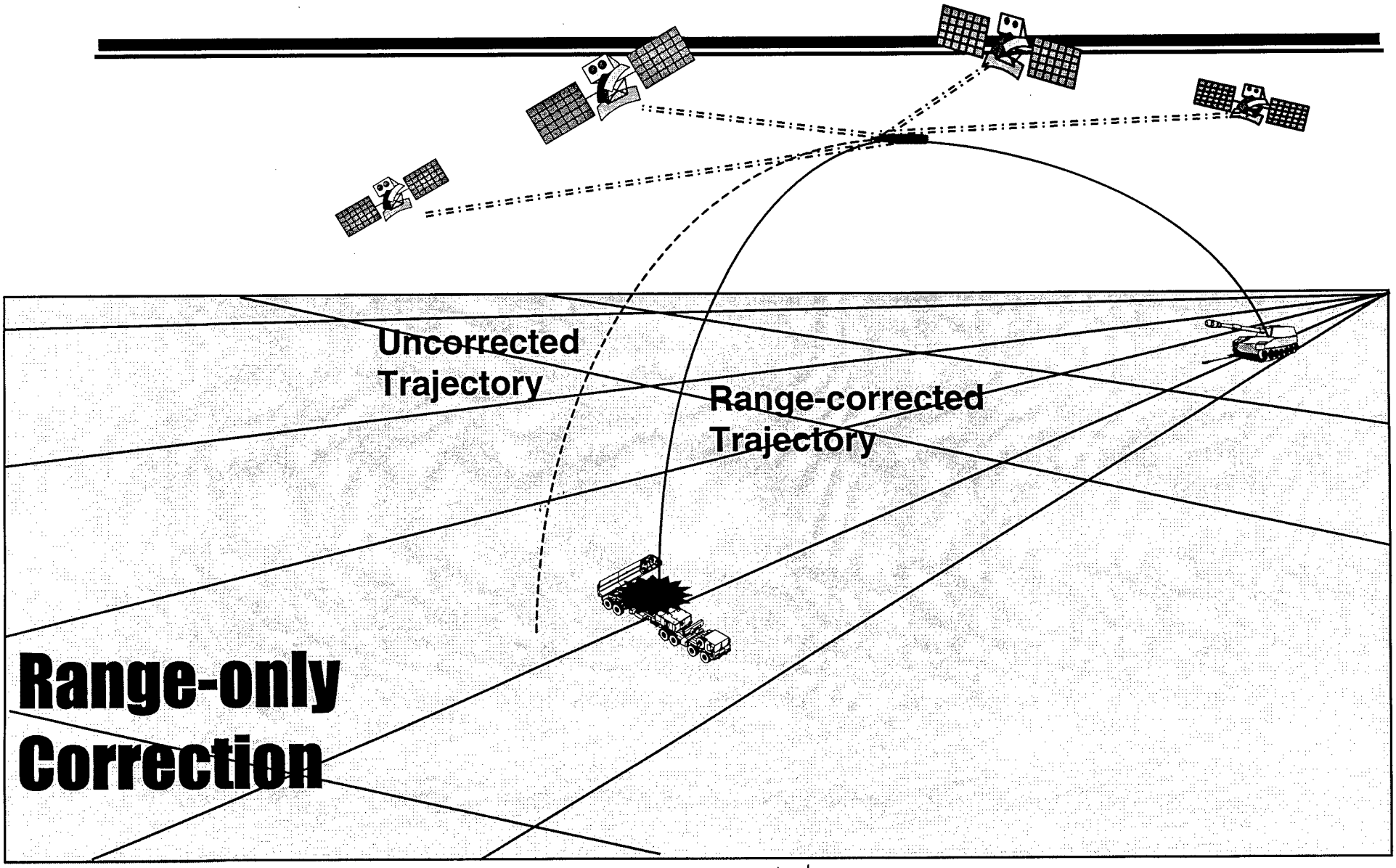
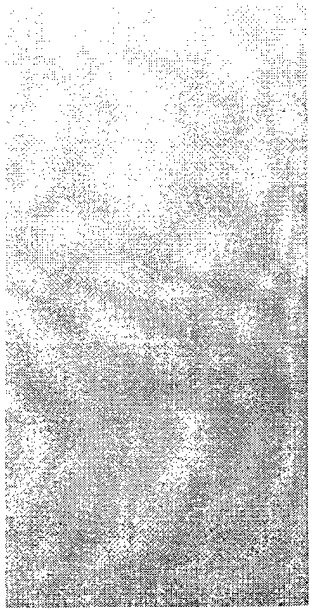


Competent Munition Technology Demonstration Program

■ Program Description

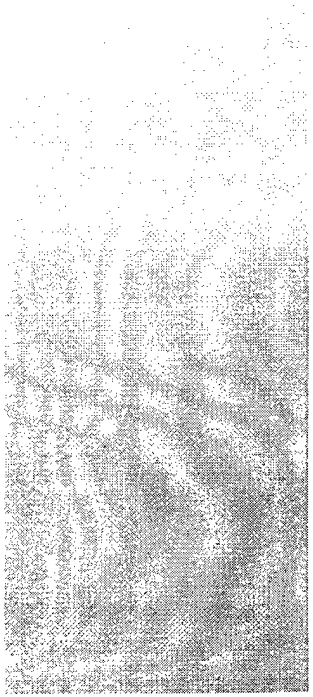
- Rockwell Collins, BAe Royal Ordnance (RO) and Thomson-Thorn Missile Electronics (TME) jointly demonstrating GPS based 1D corrected projectile
- Collins providing:
  - ➢ GPS receiver
  - ➢ Solid state data recorder
  - ➢ Antenna assembly
  - ➢ Hosting (RO) Course Correction algorithms on GPS processor
- RO providing 1D drag break technology
- TME Systems Integrator



Competent Munition Technology Demonstration Program

■ Status

- Development of fuze based components
  - ➢ *GPS Receiver / Data Recorder*
    - ■ Design complete, hardware layout in process
    - ■ Prototypes ready for integration Sept '98
  - ➢ *Collins development of fuze based antenna complete*
    - ■ Provides more consistent gain pattern for fuze applications
- Test Plans
  - ➢ *Strength of design firings 4 Q CY '98 in UK*
  - ➢ *Full functional firings 2-3 Q CY '99*



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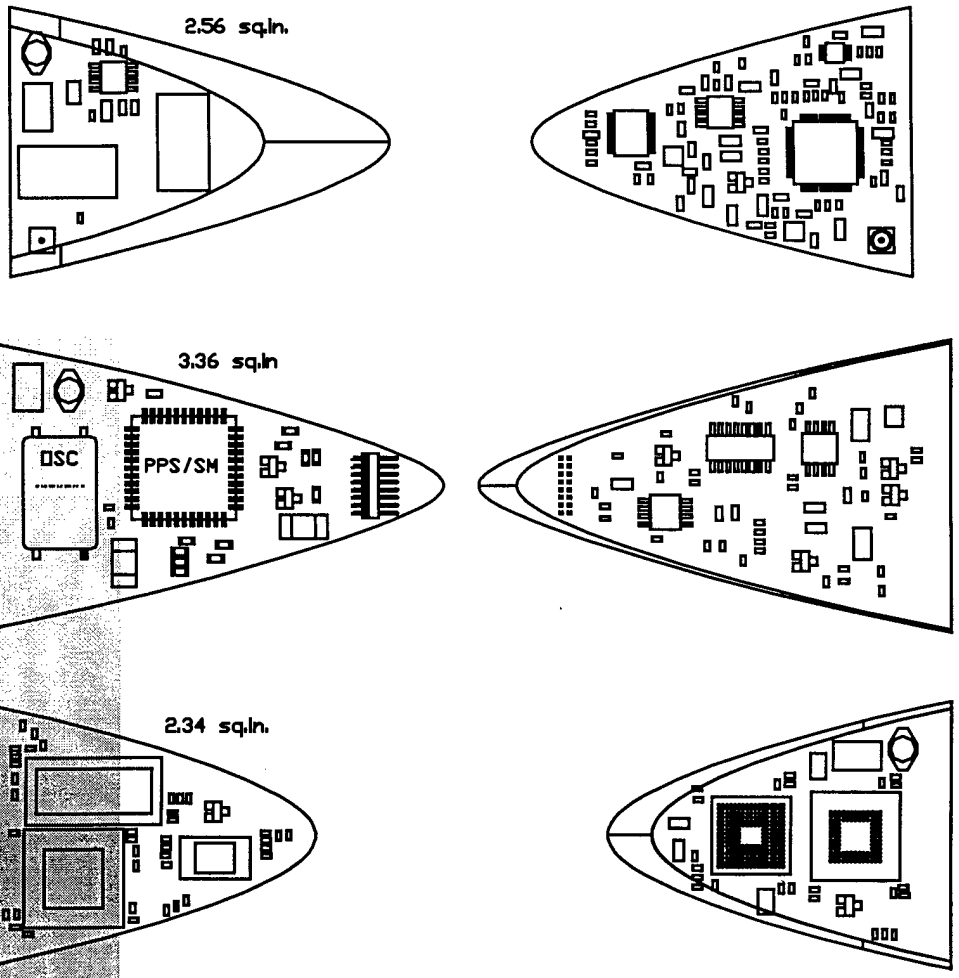
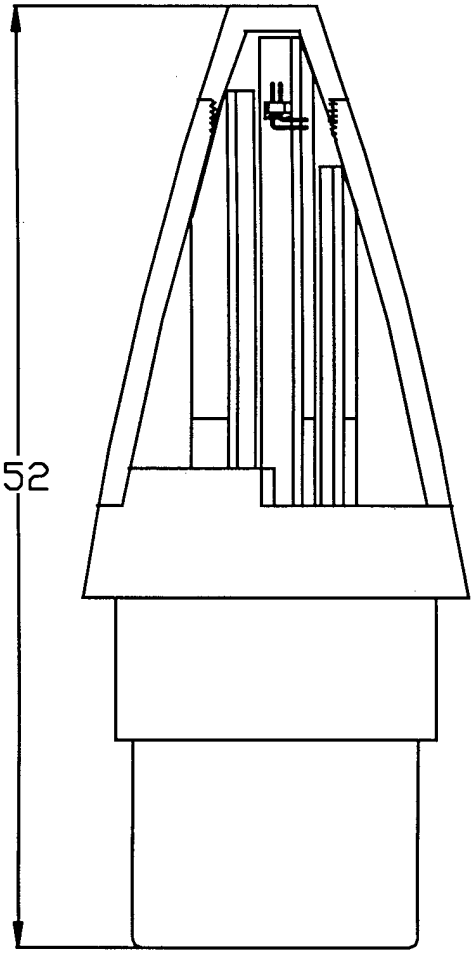
Competent Munition Technology Demonstration Program





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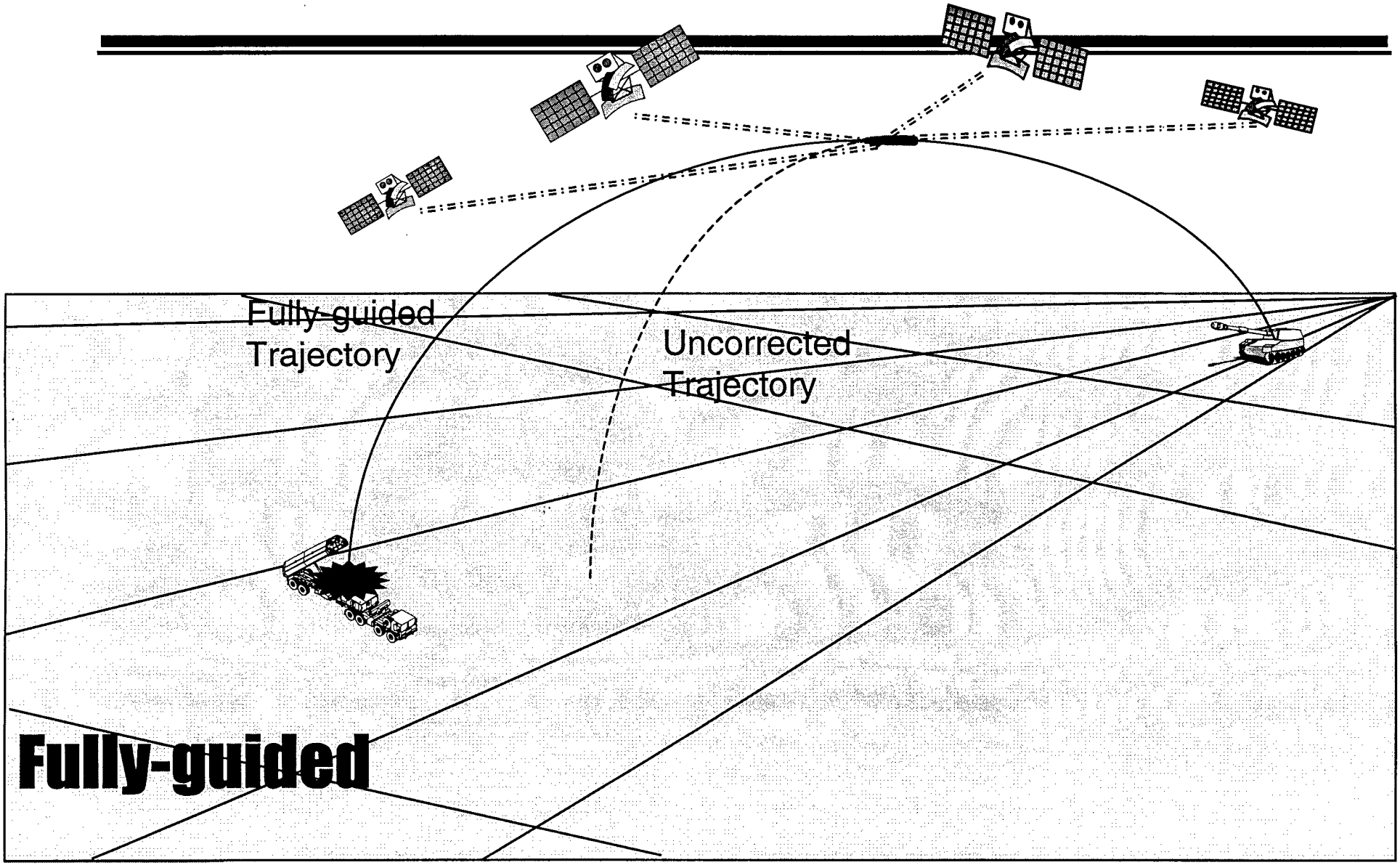


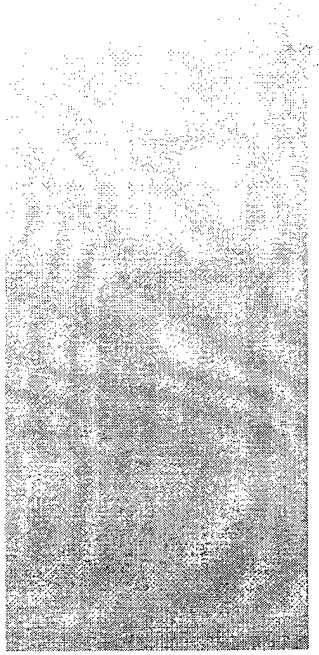
ERGM Demonstration Program

■ Extended Range Guided Munition Demo

- Technology demonstration of a GPS/INS guidance package for a rocket assisted Navy 5" Projectile
  - ➢ *Draper Laboratory (MEMS IMU and Integration)*
  - ➢ *Rockwell Collins (Modified COTS P/Y GPS receiver)*

■ Test Firing completed 11 April, 1997

- Yuma Proving Grounds
- 127 mm, (5") Navy Projectile
  - ➢ *Rocket assisted ~ 100 lb projectile*
- Key test parameters
  - ➢ *6200 g Launch Setback Shock*
  - ➢ *Altitude 40,000 ft, Range 18 nm (28.9 KM)*
  - ➢ *Achieve 20 seconds to full GPS solution*



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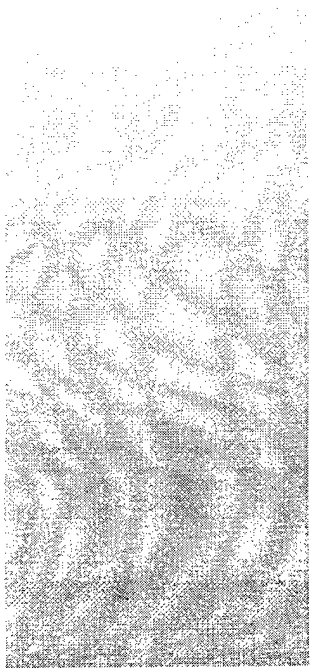
ERGM Demonstration Program

■ Results:

- Acquired First SV on Y-Code at 9.8 Sec
- Developed a 4 SV solution on Y-Code at 13.9 Sec
- Tracked the selected SV's for entire 105 Sec flight

■ Conclusions:

- Successful GPS Acquisition and Track with a Collins COTS receiver on a gunfired munition application



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Competent Munition ATD Program

■ Competent Munition ATD

- Technology demonstration of a 13 cubic inch fuze based guidance package for a Navy 5" Projectile
  - ➢ *Draper Laboratory (MEMS IMU and Integration)*
  - ➢ *Rockwell Collins (Fast Acquisition P/Y code GPS receiver)*

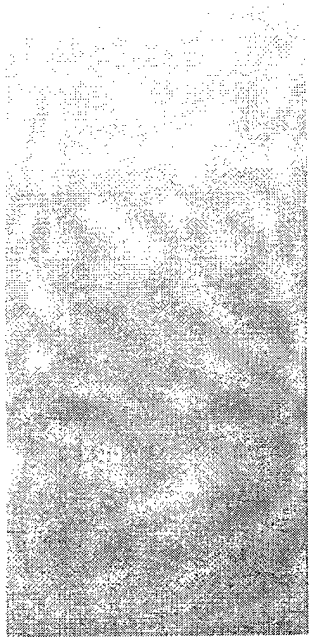
■ Engineering development completed

- 3.1 cubic inch, All-In-View, Fast direct-Y code receiver

■ Integration and test in process

■ Planned Test Firings

- Proof-of-design firing at Yuma Proving Grounds 4Q CY '98
- Full Performance Test Firings 1-2Q CY '99



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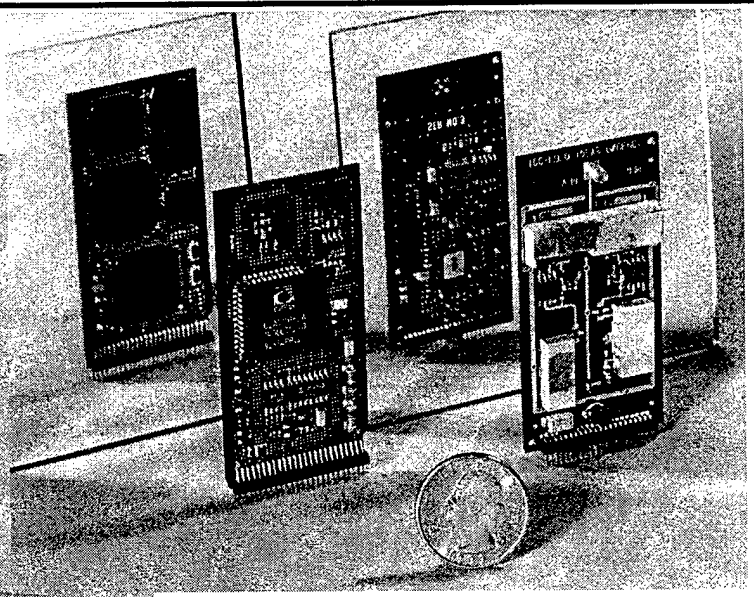
Competent Munition ATD Program



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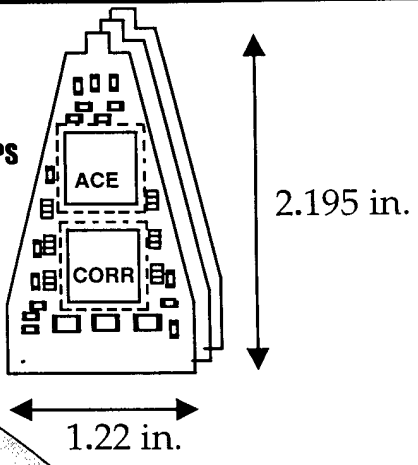
Common GPS Receiver for all Munitions Applications

Self Locating/Guidance Common Components:

- GPS Munition Receiver
- GPS Antenna
- Power Subsystem
- Fuze Setter (GPS Initialization)
- Fusing Functions



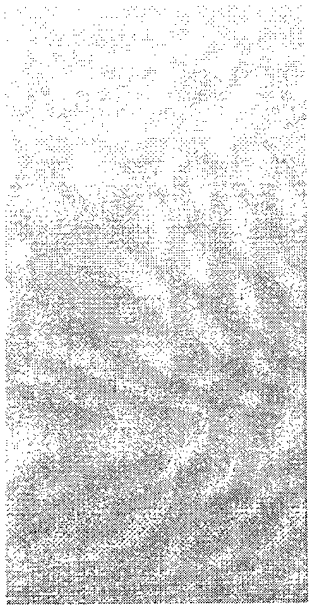
Data Link Tx/Rx & S-Band Antenna → **Auto Registration**

Drag Device → **1D Correction**

Inertial Sensors & Canard System → **2D Guidance**

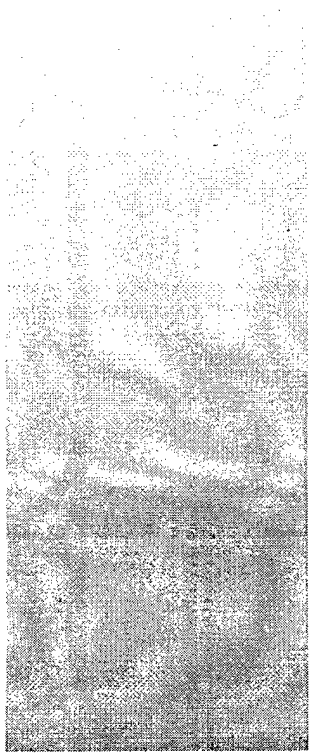
■ Fuze Based GPS Technologies

- **Antenna**
  - ➢ *Collins developed and tested prototype*
  - ➢ *Consistent gain pattern improvement over patches*
- **Oscillators**
  - ➢ *Over 200 Oscillators shock tested to > 10,000 g*
  - ➢ *9 different models from 6 vendors have been evaluated*
  - ➢ *Candidate oscillator selected, additional robustness enhancements in process*
- **Miniature High-g Receiver Technology**
  - ➢ *State-of-the-Art Chipscale packaging*
  - ➢ *Highly integrated 2-chip fast direct-Y code GPS solution*



■ Jamming

- **Current Artillery GPS Receiver Acquisition Capability is >40 dB J/S**
  - ➢ *More Than Adequate for Demonstration Programs*
  - ➢ *Adequate for Low Power Jammer Near Target scenarios*
- **Tactical Environment Needs**
  - ➢ *High Power Jammers Near Target or Low Power Jammers Closer to Gun*
  - ➢ *Rockwell Has Completed Thorough Analysis*
    - ★ NAVWAR enhancements for jamming robustness easily support mission needs for fielded artillery



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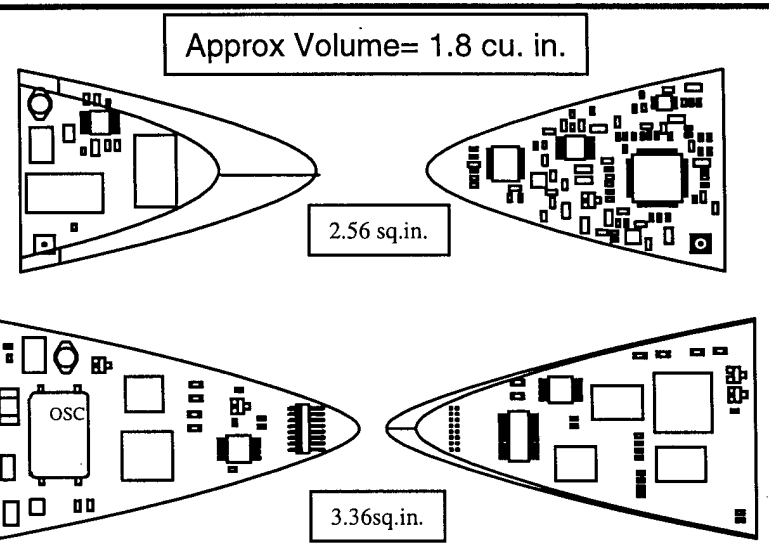
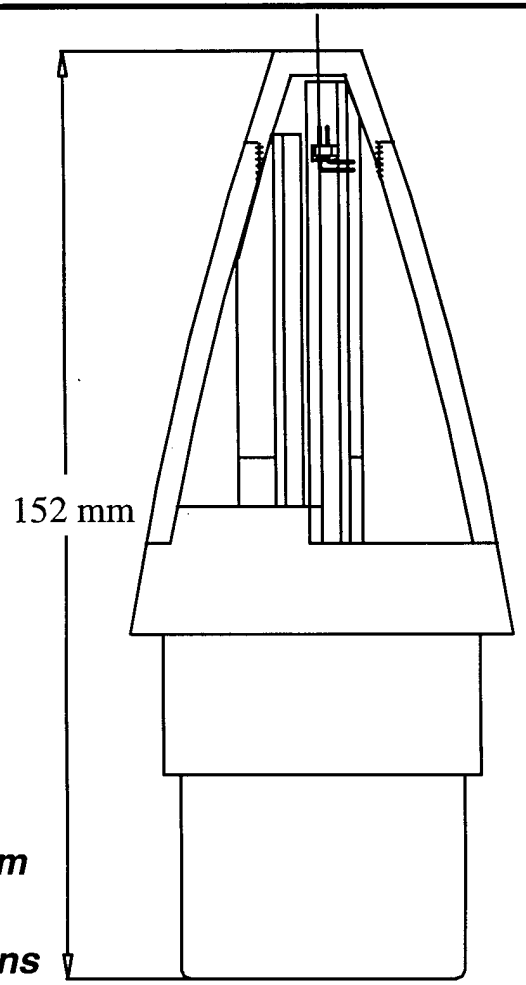
Fuze Based SAASM GPS





SAASM (Selective Availability/Anti-Spoofing Module)

- Accept and process unclassified Crypto Keys
  - ➢ *Eases Key Distribution Logistics Issues*
- Rockwell SAASM Status
  - ➢ *SAASM Supplier First SAASM Production Program (CSEL)*
  - ➢ *Chip integration plans support artillery applications*

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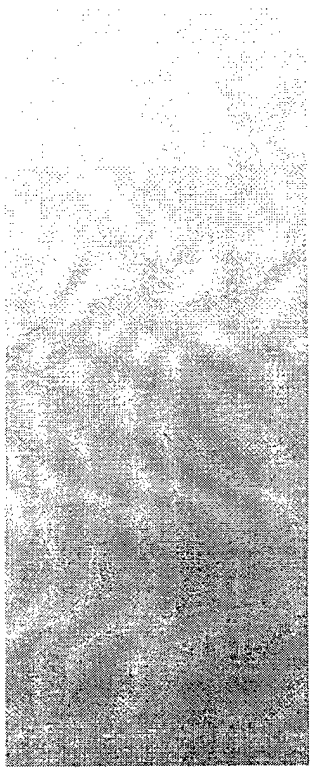
Future of GPS for Munitions

- **More resistance to jamming**
  - Both acquisition and track
- **SAASM (Selective Availability/Anti-Spoofing Module)**
  - Accept and process unclassified Crypto Keys
- **More system functionality in GPS processor**
  - Course Correction Algorithms
  - Tightly coupled system Navigation solution
  - Autopilot / Guidance
- **Smaller, Faster, Cheaper**



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Summary

- **Rockwell is committed to the GPS business**
- **Our technology investments are evidence of our continued commitment to be the P/Y GPS leader**
- **Our products span the user base for all Missile & Munition applications**
  - Artillery Shells
  - Bombs
  - Mortars
  - Missiles
  - Rockets

Rockwell provides GPS system solutions for competent munitions with technology, products, and integration expertise